Quality Assurance Project Plan

Version 2.0

Chicago, Illinois, Characterization of PM2.5 Concentrations on Union Station Train Platforms

Prepared by:

Anthony Ross
U.S. EPA Region 5
Air and Radiation Division

June 8, 2015

Section A-Project Management
A.1 Title of Plan and Approval

Quality Assurance Project Plan
Chicago, Illinois, Characterization of PM2.5 Concentrations on Union Station Train Platforms

Anthony Ross, US EPA Region 5, Air Monitoring and Analysis Section, Project Manager

_____ Date: 6-11-2015

Bilal Qazzaz, USEPA Region 5, Air Monitoring and Analysis Section, Quality Assurance Coordinator

_____ Date: 6-11-15

Loretta Lehrman, USEPA Region 5, Air and Radiation Division, Quality Assurance Manager

_____ Date: 6-11-2015

Michael Compher, USEPA Region 5, Air Monitoring and Analysis Section, Chief

_____ Date: 6/11/2015

A.2 Table of Contents

A.3 Distribution List

Anthony Ross

Bilal Qazzaz

Carolyn Persoon

Michael Compher

Loretta Lehrman

Rae Trine

Motria Caudill

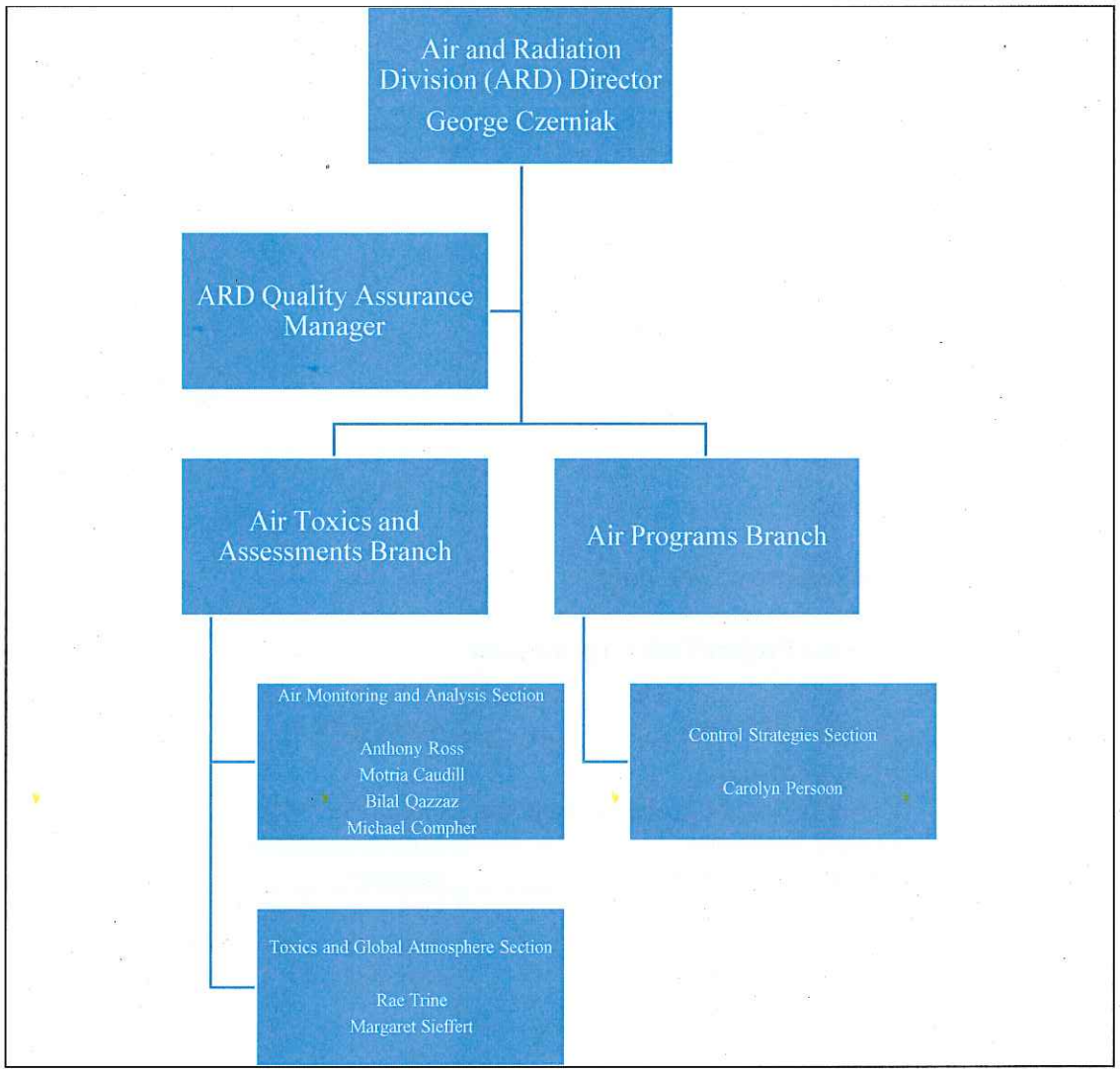
Margaret Sieffert

Quality Assurance Tracking System (Electronic Tracking)

A.4 Project/Task Organization

Individual(s) Assigned	**Responsible for:**	**Authorized to:**
Anthony Ross	Project Manager, Quality Control for Field Sampling, QAPP Revisions, Report Preparation	Coordinate Sampling Efforts, operate air monitors
Carolyn Persoon	Report Preparation, communications	Summarize data, develop/provide external communication (diesel)
Motria Caudill	Field Operator	Summarize data, operate air monitors
Rae Trine	Field Operator	Operate air monitors
Margaret Sieffert	Communications	Develop external communications
Bilal Qazzaz	Quality Assurance	Data validation
Michael Compher	Supervising Air Monitoring Efforts	Assign Work Related to Project

Figure A.1 Organization Chart 1



A.5 Problem Definition/Background

PM2.5 is particulate matter that is 2.5 micrometers (μm) in diameter and smaller. Fine particles contain microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. These health problems include: aggravated asthma, decreased lung function, and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

PM2.5 is a criteria pollutant under the Clean Air Act and therefore EPA establishes National Ambient Air Quality Standards (NAAQS) for this pollutant. Title 40 of the Code of Federal Regulations Part 50 defines ambient air as "that portion of the atmosphere, external to buildings, to which the general public has access". EPA has established an annual and 24 hour NAAQS for PM2.5. The primary annual NAAQS is 12 micrograms per cubic meter ($\mu g/m^3$) with an annual mean averaged over a three year period. The primary 24-hours NAAQS is 35 $\mu g/m^3$ using the annual 98^{th} percentile, averaged over a three year period. The Code of Federal Regulations require that only PM2.5 data that have been collected using instruments

that have been designated as Federal Reference Method (FRM), Federal Equivalent Method (FEM), or Approved Regional Method (ARM) can be compared to the NAAQS for regulatory purposes.

In 2014, researchers from the Illinois Institute of Technology (IIT) released initial results of a commuter study that took place at Union Station where they used portable photometers to measure concentrations of particulate matter (PM), ranging in size from 2.5μm to ultrafine particulates (1.0 μm or less). During a two and a half hour period of air monitoring (this sampling was part of a larger study) that focused on measuring PM2.5 concentrations outdoors, inside of Metra train cars, inside of Union Station, and on the outdoor train platforms, researchers measured a short-term PM2.5 average of 284 $\mu g/m^3$ on the outdoor train platforms. The researchers also measured a PM2.5 average of 1062 $\mu g/m^3$ on the train platforms when trains were actively moving. These short-term measurements were high relative to EPA's NAAQS, but are not an accurate representation of the way data is collected and compared to the NAAQS; which calculates design values based on three-years of data from long-term monitors. The IIT study did not utilize monitors that were designated as FRM, FEM, or APMs.

The air monitors EPA will use to characterize PM2.5 concentrations on train platforms at Unions Station are not FRM, FEM, or APMs.

Figure A.2 Study Map (Union Station)

Source: chicagounionstation.com

A.6 Project/Task Description

The purpose of this study is to allow EPA to better characterize the ambient air quality on train platforms during the commuter workday at Chicago's Union Station. EPA will use TSI SidePak™ Personal Aerosol Monitor Model AM510 monitors with 2.5µm cut-off to measure fine particulates. This air monitoring effort will take place during the daily commuter workday which will include rush hour and non-rush hour periods (from 6:00 am to 7:00 pm local time). EPA's air monitoring efforts will take place at Union Station's north and south platform, at least once a day, each weekday over a 14 day period. Sampling is scheduled to begin June 15, 2015 and the final date of sampling is scheduled for July 2, 2015.

A.7 Quality Objectives & Criteria

EPA's main objective for air monitoring at Union Station is to characterize average PM2.5 concentrations of the ambient air on the train platforms during the daily commuter workday. The data completeness goals for this project will be measured in days sampled. Therefore, the completeness goal of this project is to conduct air monitoring on the train platforms, at least once a day for 14 weekdays. The duration of each individual field sampling event will depend on a number of factors, but the goal is to have each field operator survey the platform(s) using the portable SidePak™ Personal Aerosol Monitor Model AM510 for at least an hour per sampling event. If any stationary sampling takes place during this project, the goal is to collect as much data as possible per stationary sampling event. There will also be a number of collocated air monitoring comparisons done during this study. A sampling event is defined as the air monitoring data that is collected by a single field operator from the time they start to collect data (leaving Region 5 office) until the time they finish collecting data (returning to Region 5 office). A test refers to intermittent sampling during a sampling event.

The aerosol concentration range of the SidePak™ Personal Aerosol Monitor Model AM510 is from 0.001 to 20 mg/m^3, with a minimum resolution of 0.001 mg/m^3. The monitor's manufacturer, TSI conducts annual certifications of the SidePak™ optical sensor based on an instruments response to an a known aerosol concentration. The concentration linearity plot for certifications runs from 0.01 mg/m^3 and 100 mg/m^3 with tolerance points between 0.100-0.500 mg/m^3 and 10 mg/m^3. With tolerance acceptance points of +/- 10% between the standard and an instruments readings.

A.8 Special Training/Certifications

EPA personnel will be trained to operate the monitors used in this study as per the User's Guide (Manual) and follow the written Standard Operating Procedure for the SidePak™ Personal Aerosol Monitor Model AM510 R5-ARD-0004-r0. All quality control/quality assurance checks will be performed by EPA personnel trained to perform these responsibilities.

A.9 Documents and Records

The Project Manager will be responsible for ensuring that:

- All QAPP revisions are shared with project participants. Each revision of the QAPP will be numbered and dated.
- Each monitor will have its own dedicated logbook that will be kept accessible to those involved in the field sampling.
- A binder will be kept in a secured location for all of the additional field data sheets needed to document project field activities.

- The field data sheets will document any quality control activities, instrumentation issues, as well as important observations made in the field.

Electronic data collection will take place using the SidePak™ which stores the air monitoring data it collects in its internal memory. After each sampling event,field data will be downloaded to a computer using the TSI TrakPro™ Data Analysis Software and a Universal Serial Bus (USB) communications cable.

A copy of this QAPP and the Standard Operating Procedure will be readily available to all project participants. An electronic copy of both documents will be uploaded to the EPA QA Tracks database. All data will be stored in secured locations and write access to data files are granted only to the Project Manager and data reviewer. This project will be archived on the QA Tracks database for a length of time based on EPA's record retention schedules.

Section B- Data Generation & Acquisition

B.1 Sampling Process Design

Approximately three weeks of PM2.5 air monitoring data will be collected on the north and south platforms at Union Station. The monitoring data will be used to characterize average PM2.5 concentrations on the train platforms during the rush hour and non-rush hour periods. The monitoring will begin in mid-June of 2015.

B.2 Sampling Methods

The SidePak™ Personal Aerosol Monitor Model AM510 is a miniature battery-operated continuous instrument that takes an aerosol measurement once every second and stores collected data to its internal memory. The monitor can operate in "survey mode", but no data is stored in the monitor's internal memory using "survey mode". All data will be collected in the "data log" mode, which allows for air quality data collected to be stored to the SidePak's™ internal memory.

Field operators, sampling with three separate SidePak™ instruments (or at a minimum two) simultaneously, will begin and end each sampling event collecting background ambient air quality data walking down predefined routes on their way to and from Union Station (there is a post-sampling zero test that will be performed at the end of each sampling event). Since the SidePak™ should not be operated in the rain, during periods of rainy weather, ambient background data can be collected outside of Union Station where outdoor shelter may be provided from the rain. See Figure B.1 for predefined routes map.

Field operators will survey the north and south platforms at scheduled sampling times collecting one minute PM2.5 data that will be averaged over a one hour period. The field operator(s) surveying the platforms will be collecting PM2.5 data between two and three hour periods. Although it will not always be possible to collect complete hours due to field work logistics (zero calibrations, switching platforms, etc.), 45 minutes of data collected on a platform will be sufficient to determine an hourly average for a given platform. The scheduled sampling times will take place during the Union Station rush hour and non-rush hour periods (see Appendix A of this QAPP for the proposed sampling schedule).

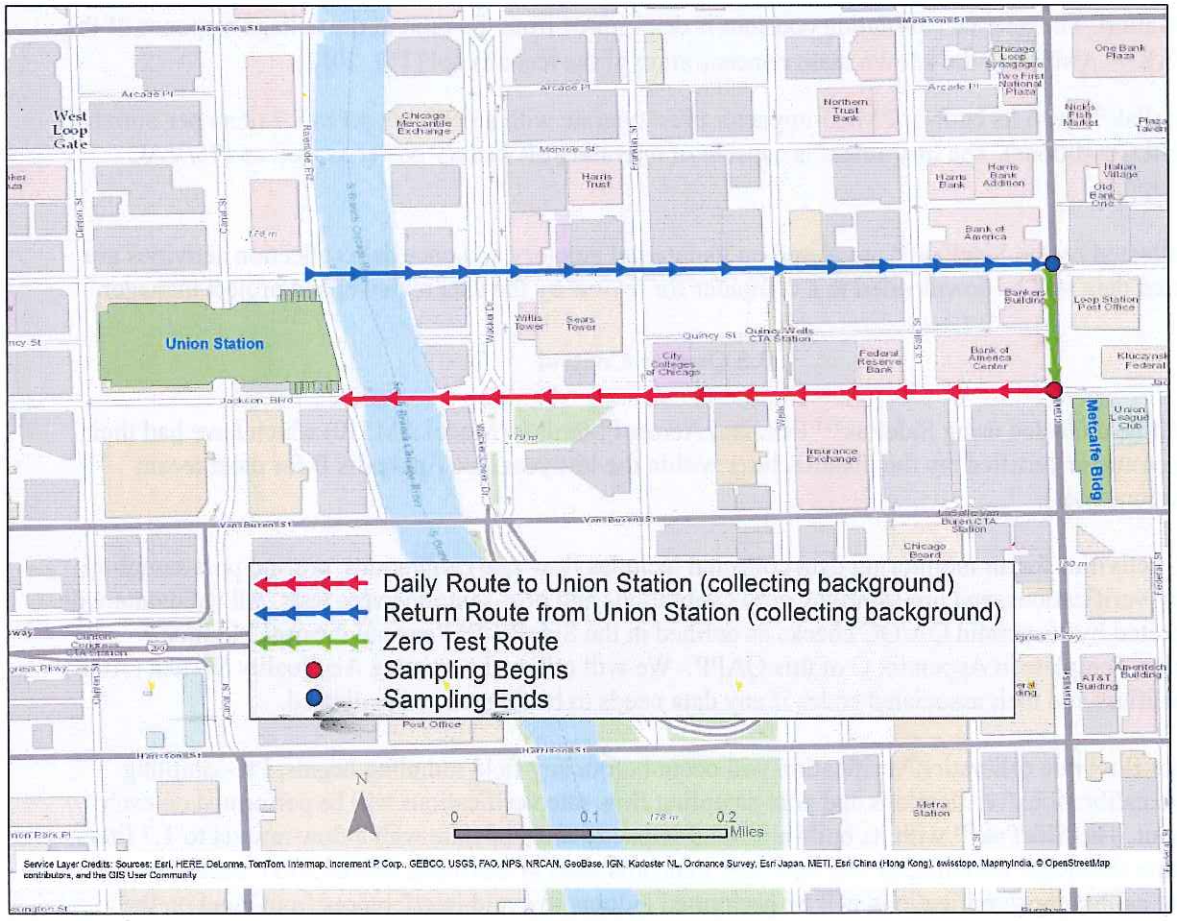
Since air quality data will only be collected on the train platforms, and field operators needs to go indoors to move from one platform to another, they must stop the monitor's data logging "test" (the first test in a sampling event would automatically be named "test 1" in the monitor's internal memory), and restart another data logging "test" (this would automatically be named "test 2" in the internal memory). A test refers to intermittent air quality sampling data stored in the memory of the SidePak™ during a sampling event. Multiple test will take place during each sampling event. Using the data logging test function of the SidePak™ along with detailed field notes will provide identification of when and where air monitoring data was collected. For example, "test 1" would start once the field operator starts walking to Union Station. Before the field operator enters the building (Union Station), they will stop the test to avoid sampling indoor air. Once the field operator is on the train platform, they will start "test 2", etc. The internal memory of each SidePak™ must be cleared before each sampling event in order to ensure that the first test during a sampling event will be titled "test 1". Failure to clear the memory will result in a continuation of tests titled in sequential order from the previous sampling event (e.g. if the last test of the previous sampling event was "test 5" the first test of the new sampling event would be titled "test 6").

Although the monitor stores date and time information, field staff will take detailed notes using the Field Data Sheets about locations of each test, as well as document any other pertinent information. As already mentioned EPA will monitor PM2.5 on the north and south platforms, particularly train platforms that are closest to the Chicago River and train platforms that are furthest from the river. EPA will also monitor PM2.5 focus on other platforms where there are passengers boarding trains and/or have idling trains. EPA may not have access to all platforms on any given day due to assignment of tracks to Metra by Amtrak and the building/station owners.

Once a scheduled sampling event is completed, the field operator or project manager will download the data to a computer from each instrument. The project manager will also conduct any Quality Assurance (QA) and post-sampling Quality Control (QC) checks.

The field operators will utilize the Standard Operating Procedure (SOP) as well as the manufacturer's "User Guide" to operate the SidePak™ Personal Aerosol Monitor Model AM510 for data collection activities.

Figure B.1 Predefined Routes for Collecting Ambient Air Background Data and Post Sampling Zero Test Route



B.3 Sampling Handling & Custody

The SidePak™ Personal Aerosol Monitor Model AM510 analyzes aerosol concentrations within the instrument. There are no sampling media (sample filters, etc.) used for this particular monitoring method and therefore a Chain-of-Custody is not needed. When not deployed to collect data, the SidePak™ instruments will be stored in a controlled access room in EPA's Region 5 Office.

B.4 Analytical Method

The SidePak™ Personal Aerosol Monitor Model AM510 is a portable, lightweight, battery-operated laser photometer that measures real-time airborne Particulate Matter (PM) mass concentrations in milligrams per cubic meter (mg/m^3). The instrument uses light scattering technology to measure mass aerosol concentrations from a continuous stream of air that is drawn in through the sampling train and into the sensing chamber by the internal sampling pump. One section of the aerosol stream is illuminated with a small beam of laser light. Particles in the aerosol stream scatter light in all directions. A lens at 90° to

both the aerosol stream and laser beam collects some of the scattered light and focuses it onto a photodetector. The detection circuitry converts the light into a voltage. This voltage is proportional to the amount of light scattered which is, in-turn, proportional to the mass concentration of the aerosol. The voltage is read by the processor and multiplied by an internal calibration constant to yield mass concentration. The internal calibration constant is determined from the ratio of the voltage response of the SIDEPAK™ AM510 to the known mass concentration of the test aerosol (TSI, 2012).

The SidePak™ with its built-in PM2.5 impactor must operate with a flow rate set to 1.7 liters per minute (Standard Conditions). The instrument is capable of operating off battery power as well as 115/VAC power supply.

Data collected by the SidePak™ are stored on its internal memory and once data collection activities are completed data will be downloaded to a computer for review by the data reviewer and project manager.

B.5 Quality Control

Data will be collected using SidePak™ Personal Aerosol Monitor (Model AM510) which have had their laser photometer certified by the manufacturer within the last year (see Appendix B for most recent certification dates).

QA/QC activities for air monitoring data collected includes flow rate calibrations, pre and post-sampling flow rate verifications, and pre-sampling zero calibrations and post-sampling zero tests. All valid data will be bracketed by successful QA/QC checks as defined in the SidePak™ Personal Aerosol Monitor Validation Template in Appendix C of this QAPP. We will utilize the existing Air Quality System (AQS) data qualifiers and their associated codes if any data needs to be flagged or invalidated.

An initial flow rate calibration/verification will occur before any field sampling begins. Pre-sampling flow rate calibrations/verifications and post-sampling flow rate verifications will be performed on each instrument. The SidePak™ with its built-in PM2.5 impactor must operate with a flow rate set to 1.7 liters per minute (Standard Conditions). All flow rate standards used in this study will be NIST traceable. All flow rate calibrations/verifications will be performed indoors to avoid interferences from wind on the flow rate standard

A flow rate audit on each SidePak™ monitor will be performed by EPA personnel independent of data generating activities using a separate NIST traceable flow standard from that which is used to perform routine flow rate calibrations/verifications.

A zero calibration will be performed and documented on instruments prior to each test that occur within a sampling event. Each SidePak™ monitor comes equipped with a zero filter that is used to calibrate the instrument's zero readings. Calibrating the instrument's zero will help to ensure that accurate data will be collected. A post sampling zero test will be performed and documented on instruments at the end of each sampling event.

Collocated sampling events will take place daily throughout the study. Collocated sampling involves running all three SidePak™ (or at a minimum two) instruments simultaneously at the same location with the instruments attached to the same field operator. Since the inlets of all three monitors will be attached to the collar of the field operator, we will not allow any of the inlets to touch another inlet in order to avoid biasing air flows. Collocated data will determine how well multiple instruments compare when sampling under the same conditions and we will calculate a percent different between all collocated

instruments. Due to the use of non-reference and equivalent instrumentation of this study, collocation will also help evaluate what the expected precision data quality objectives should be for the SidePak™. The collocated sampling will allow of the instruments to malfunction, and still have valid data collected with the other two instrument that are part of the collocation.

Data verification/validation or the possible flagging or invalidation of data will be based on meeting the QA/QC checks below, also outlined in Appendix C of this QAPP.

- The acceptance criteria for One-Point Flow Rate Verifications and Flow Rate Audits is 1.7 SLPM +/-5% (Flow Standard VS. 1.7 SLPM). If limits falls outside of these specifications. Data will be flagged up to 10% and invalidated after the 10% criteria is exceeded.

  The calculation for percent differences between flow rate standards and 1.7 SLPM is

$$\frac{\text{Flow Standard Reading in SLPM} - 1.7\ \text{SLPM}}{1.7\ \text{SLPM}} * 100$$

- The data quality objective goals for instrument collocation is 0.015 mg/m³ or 30 percent difference, whichever is greater between all instruments per test. Data will not be necessarily invalidated if these objectives are not met, but further investigation would be required to determine if there are any instrumentation issues contributing to the large percent difference.

- Zero calibrations performed prior to each test should read between 0.000-0.001 mg/m³. Failure to meet this criteria will result in performing an additional zero calibration to have the SidePak™ read as close to 0.000mg/m³ as possible.

- Post sampling zero tests will be performed after each sampling event to test the instruments response when sampling air being drawn through a HEPA filter. Results of the zero tests will be logged in the internal memory of the SidePak™ and graphed and reviewed throughout the project to ensure there is no positive drift in PM2.5 concentrations over time. A positive value could indicate an issuewith either the monitor or a a particular HEPA filter.

Setting and tracking that the current date and time (local time – 24 hour format) stored in the memory of the SidePak™ is accurate is critical to this study. Date and time will be verified before and after each sampling event.

The nickel-metal hydride (NiMH) battery packs for the SidePak™ will be fully charged before each sampling event.

Detailed information on the QA/QC procedures can be found in the SidePak™ Personal Aerosol Monitor Model AM510 SOP. A QA/QC validation template for this project is presented in Appendix C. The manufacturer's Users Guide provides only a single value for standard flow rate using the PM2.5 impactor. We will follow EPA's PM2.5 flow rate requirements for regulatory PM2.5 monitoring, which allows for flow to be +/- 5% of the design flow.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

The project manager and field operators will perform quality control checks such as pre- and post-sampling flow rate calibrations/verifications and pre sampling zero calibrations. If any of the quality control checks are out of specification, field staff will try to correct the issue. If there are any issues beyond the knowledge of the field staff, the vendor will be consulted. If the vendor cannot provide adequate technical support, then the problematic instrument will be sent to the vendor for repair. If the sampling instrumentation meets the acceptance criteria, it will be assumed that the instrumentation is operating properly.

The SidePak™ requires periodic maintenance as per the manufacturer's user guide. The periodic maintenance for charging the NiMH Battery Packs, zero calibrations, and PM2.5 impactor maintenance will be documented and followed as per the Standard Operating Procedure for the SidePak™ Personal Aerosol Monitor Model AM510 R5-ARD-0004-r0 and manufacturer's user guide. Annual factory-authorized cleaning and recalibration will be performed by the manufacturer.

There are a number of items to inspect before any field sampling takes place. All periodic preventative maintenance will occur based on the manufacturer's User Guide.

The SidePak™ Personal Aerosol Monitor Model AM510 will be maintained following the "SidePak™ Personal Aerosol Monitor Validation Template" presented in Appendix C.

B.7 Instrument/Equipment Calibration and Frequency

Each SidePak™ Personal Aerosol Monitor Model AM510 will be sent to the manufacturer at least once a year for factory-authorized cleaning and recalibration of the instrument. Periodic flow rate calibrations will be conducted by the project manager and field staff.

B.8 Inspection/Acceptance of Supplies

All of the monitors will be tested and inspected before data collections activities occur. If there are any issues with, or damages to, any of the instruments, we will contact the manufacturer and remedy the issue.

Section C – Assessments and Oversight

C.1 Assessment and Response Actions

Assessments are designed to determine whether the Quality Assurance Project Plan is being implemented as approved (conformance/nonconformance), to increase confidence in the information obtained, and ultimately to determine whether the information may be used for the intended purpose.

At least one technical assessment will be conducted on the air flow rates of each monitor used in this study using NIST traceable flow standards. The assessment will be conducted by a party independent of data generating activities using a flow standard different from the flow standard used to calibrate/verify any of the instruments used in this study.

C.2 Reports to Management

The project manager will summarize data results weekly throughout the duration of the project. The weekly summaries will address data concentrations and any project implementation issues. A number of participants involved in this project will be responsible for writing a final report. The final report will provide an in-depth summary of the data, as well as consolidate quality control and quality assurance findings. The final report will be made publicly available.

Section D – Data Validation and Usability

D.1 Data Review, Verification, and Validation

Raw data will be reviewed by the project manager and data reviewer prior to performing any statistical calculations. Field data sheets will also be reviewed by the project manager and field operators to ensure accurate transcription. Data collected by the SidePak™ are stored on its internal memory and once data collection activities are completed data will be downloaded to a computer for review by the project manager and data reviewer. No physical samples (sampling filter media, etc.) will be handled as part of this data collection effort.

D.2 Verification and Validation Methods

Data will be collected using SidePak™ Personal Aerosol Monitor (Model AM510) which have had their laser photometer certified by the manufacturer within the last year (see Appendix B for most recent certification dates). All valid data collected will be bracketed by:

- Flow rate calibrations/verifications that meet quality assurance/quality control acceptance criteria identified in this QAPP.
- Pre-sampling zero calibration.
- All ambient concentration data and Field Data Sheets will be reviewed to determine if the data is of known quality, or if data needs to be flagged or invalidated. To standardize data qualifiers, we will utilize the existing Air Quality System (AQS) data qualifiers and their associated codes if any data needs to be flagged or invalidated.

Documentation of equipment and instrumentation calibration are detailed in the Standard Operating Procedure for the SidePak™ Personal Aerosol Monitor Model AM510 R5-ARD-0004-r0.

D.3 Reconciliation with User Requirements

The project manager and data reviewer will conduct periodic data reviews throughout the duration of the project to determine if DQOs listed in Section A.7 are being met. The purpose of these data reviews are to uncover limitations on using the data, discover outliers, and to determine if there are any data quality issues. The project manager and data reviewer will be responsible for conducting statistical analysis which may include creating summary statistics, or using graphs and charts to interpret information. Data will be determined valid, if the data quality objectives are met (quality assurance/quality control criteria).

References

Agency, United States Environmental Protection. (2013, May). *QA Handbook for Air Pollution Measurement Systems Volume II Ambient Air Quality Monitoring Program* . Retrieved from http://www.epa.gov/ttnamti1/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf

Chicago Union Station. (2015). *Chicago Union Station.* Retrieved from Chicago Union Station: http://www.chicagounionstation.com/map_concourse.html

Stephens, B. (2014). *Particulate matter on Metra commutes.*

TSI. (2012). *SIDEPAK™ AM510 PERSONAL AEROSOL MONITOR THEORY OF OPERATION.* Retrieved from http://www.tsi.com/uploadedFiles/_Site_Root/Products/Literature/Application_Notes/ITI-085.pdf

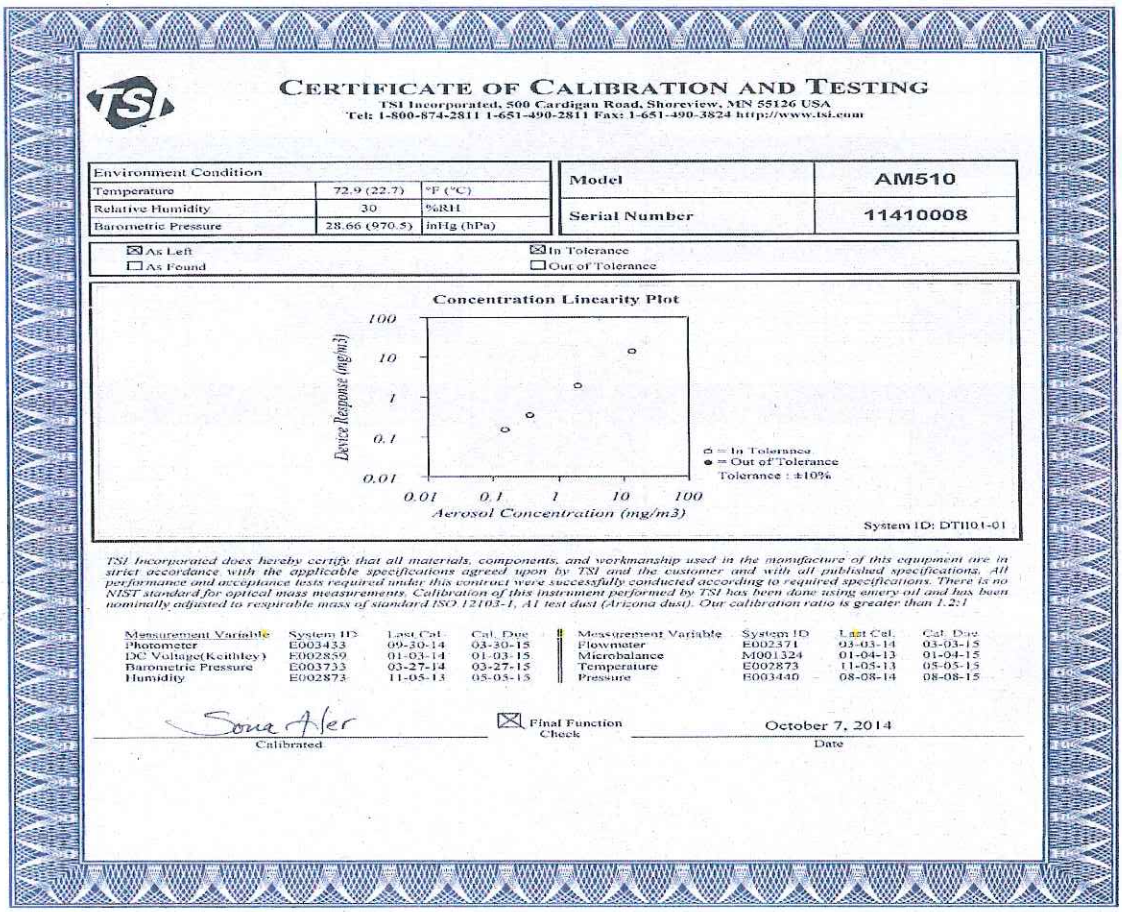
Appendix A - Proposed Monitoring Schedule

	6:00:00 AM	7:00:00 AM	8:00:00 AM	9:00:00 AM	10:00:00 AM	11:00:00 AM	12:00:00 PM	1:00:00 PM	2:00:00 PM	3:00:00 PM	4:00:00 PM	5:00:00 PM	6:00:00 PM
Day 1	North Platform								North Platform				
Day 2	South Platform								South Platform				
Day 3				North Platform							North Platform		
Day 4				South Platform							South Platform		
Day 5							North Platform						
Day 6				South Platform							South Platform		
Day 7				North Platform							North Platform		
Day 8	South Platform								South Platform				
Day 9	North Platform								North Platform				
Day 10							South Platform						
Day 11	North Platform						North Platform						
Day 12	South Platform						South Platform						
Day 13											South Platform		
Day 14											North Platform		

North Platform

South Platform

Appendix B - SidePak™ Personal Aerosol Monitor Model AM510 Manufacturer's Annual Certification and Flow Standard Certification



CERTIFICATE OF CALIBRATION AND TESTING

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 http://www.tsi.com

Environment Condition		
Temperature	72.9 (22.7)	°F (°C)
Relative Humidity	30	%RH
Barometric Pressure	28.66 (970.5)	inHg (hPa)

Model	AM510
Serial Number	11410008

☒ As Left ☐ As Found

☒ In Tolerance ☐ Out of Tolerance

Concentration Linearity Plot

System ID: DTI101-01

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass of standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1

Measurement Variable	System ID	Last Cal.	Cal. Due	Measurement Variable	System ID	Last Cal.	Cal. Due
Photometer	E003433	09-30-14	03-30-15	Flowmeter	E002371	03-03-14	03-03-15
DC Voltage(Keithley)	E002859	01-03-14	01-03-15	Microbalance	M001324	01-04-13	01-04-15
Barometric Pressure	E003733	03-27-14	03-27-15	Temperature	E002873	11-05-13	05-05-15
Humidity	E002873	11-05-13	05-03-15	Pressure	E003440	08-08-14	08-08-15

Sona Aler
Calibrated

☒ Final Function Check

October 7, 2014
Date

CERTIFICATE OF CALIBRATION AND TESTING

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 http://www.tsi.com

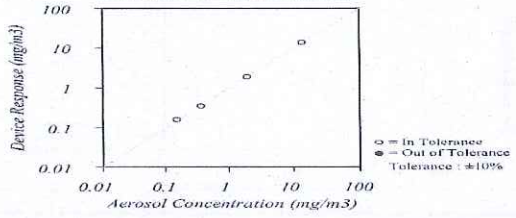
Environment Condition		
Temperature	72.9 (22.7)	°F (°C)
Relative Humidity	30	%RH
Barometric Pressure	28.66 (970.5)	inHg (hPa)

Model	AM510
Serial Number	11410011

☒ As Left ☐ As Found

☒ In Tolerance ☐ Out of Tolerance

Concentration Linearity Plot



System ID: DTI101-01

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass of standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1

Measurement Variable	System ID	Last Cal.	Cal. Due	Measurement Variable	System ID	Last Cal.	Cal. Due
Photometer	E003433	09-30-14	03-30-15	Flowmeter	E002371	03-03-14	03-03-15
DC Voltage(Keithley)	E002859	01-03-14	01-03-15	Microbalance	M001324	01-04-13	01-04-15
Barometric Pressure	E003733	03-27-14	03-27-15	Temperature	E002873	11-05-13	05-05-15
Humidity	E002873	11-05-13	05-05-15	Pressure	E003440	08-08-14	08-08-15

Sona Her
Calibrated

☒ Final Function Check

October 7, 2014
Date

CERTIFICATE OF CALIBRATION AND TESTING

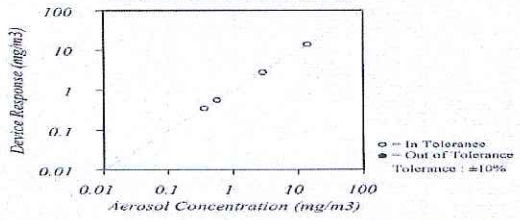
TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 http://www.tsi.com

Environment Condition		
Temperature	73.0 (22.8)	°F (°C)
Relative Humidity	24	%RH
Barometric Pressure	28.99 (981.7)	inHg (hPa)

Model	AM510
Serial Number	11410013

☒ As Left ☐ As Found
☒ In Tolerance ☐ Out of Tolerance

Concentration Linearity Plot



System ID: DTI101-01

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. There is no NIST standard for optical mass measurements. Calibration of this instrument performed by TSI has been done using emery oil and has been nominally adjusted to respirable mass of standard ISO 12103-1, A1 test dust (Arizona dust). Our calibration ratio is greater than 1.2:1

Measurement Variable	System ID	Last Cal.	Cal. Due	Measurement Variable	System ID	Last Cal.	Cal. Due
Photometer	E003433	09-30-14	03-30-15	Flowmeter	E002371	03-03-14	03-03-15
DC Voltage(Keithley)	E002859	01-03-14	01-03-15	Microbalance	M001324	01-04-13	01-04-15
Barometric Pressure	E003733	03-27-14	03-27-15	Temperature	E002873	11-05-13	05-05-15
Humidity	E002873	11-05-13	05-05-15	Pressure	E003440	08-08-14	08-08-15

Calibrated

☒ Final Function Check

October 8, 2014
Date

Mass Flowmeter Calibration Certificate

Model 4146 Revision D
Serial Number 41461437018

Flowmeter Calibration Verification

Calibration Date Fri 12-Sep-2014 05:06
Verification Date Fri 12-Sep-2014 05:14
Temperature 21.3 °C
Pressure 14.45 psia

Air - As Left
Tolerance: 1.75% reading or 0.005 SLPM

Actual (SLPM)	Measured (SLPM)	Difference (%)	Tolerance (%)
0.033	0.032	-3.1	-20
0.177	0.177	0.1	4
0.301	0.300	-0.3	-16
0.403	0.397	-1.4	-78
1.005	0.996	-0.9	-52
1.996	1.985	-0.6	-32
3.709	3.656	-1.4	-82
7.510	7.533	0.3	17
14.94	14.84	-0.7	-39

Temperature - As Left
Tolerance: ±1.000 °C

Actual (°C)	Measured (°C)	Difference (%)	Tolerance (%)
21.36	21.31	-0.20	-4

Pressure - As Left
Tolerance: ±0.110 psia

Actual (psia)	Measured (psia)	Difference (%)	Tolerance (%)
14.45	14.44	-0.05	-7
21.77	21.77	-0.00	-0

This flowmeter has been calibrated on the TSI Flowmeter Calibration Facility (TSI 9120254) using the procedures outlined in TSI 9010581. The calibration of the Flowmeter Calibration Facility maintains NIST traceability in accordance with TSI 9120254.

TSI Standard Conditions: 70 °F (21.11 °C) and 14.7 psia

Verified By: Enesa Begic

Calibration Reference(s)	
Reference	Due for Calibration
E005067	22-Jan-2015
E005068	22-Jan-2015
E005069	22-Jan-2015

Shipping Address: TSI Inc., 500 Cardigan Rd, Shoreview, MN 55126 USA

Printed: Friday 12-Sep-2014 10:41

Appendix C - SidePak™ Personal Aerosol Monitor Validation Template

Criteria (PM2.5)	Frequency	Acceptable Range	Information/Action
Quality Control/Quality Assurance Criteria/Goals			
**One-Point Flow Rate Verification	Before and after each sampling event	1.7 SLPM +/-5% (Flow Standard VS. 1.7 SLPM)	User Guide/ EPA QA Handbook
**Flow Rate Calibration	As needed/determined by flow rate verification results. Calibrations will occur as often as necessary to maintain flows as close as possible to 1.7 SLPM	1.7 SLPM +/-5% (Flow Standard VS. 1.7 SLPM)	User Guide/ EPA QA Handbook
Zero Calibration	Prior to every test	0.000 – 0.001 (must document results)	User Guide
Post-Sampling Zero Test	At the end of every sampling event	Results will be analyzed over time	Best Practice
***Collocated Runs	Every sampling event	0.015 mg/m³ or 30 percent difference, whichever is greater between all instruments per test.	NA
Flow Rate Audits	At least one per project	1.7 SLPM +/-5% (Flow Standard VS. 1.7 SLPM)	User Guide/ EPA QA Handbook
Operational Criteria			
Cleaning Impactor, Impactor Inserts, and Greasing Impactor Inserts	Prior to each use	NA	User Guide
Cleaning the Tygon Tubing	As needed per visual inspection. At least once a week	NA	Manufacturer's Recommendation
Charging Nickel-Metal Hydride (NiMH) Battery Packs	Prior to each use	NA	User Guide
Operating Temperature	NA	0° C to 50° C (32° F to 120° F)	User Guide
Operational Humidity	NA	0 to 95% RH, non-condensing	User Guide

**** Indicates that the TSI Model 4146 Mass Flow Calibrator sensors cause ghost flow readings between 0.008 – 0.013 SLPM. EPA consulted with TSI and this was found to be a non-issue regarding instrument performance.**

***** Indicates that precision of instruments is unknown at low concentration limits. Therefore we will calculate percent difference throughout project to establish what type of precision should be expected for future studies.**